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Management and assessment of innovation environments

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Abstract

This article describes and assesses the management of innovation environments, such as business incubators and science, technology, and innovation parks, resulting from university-industry-government (UIG) linkages. It also reviews recent literature in which three different methods are presented and combined: Da Poian's 11 factors, Estrategigram, and the method Centro de Referência para Apoio a Novos Empreendimentos (CERNE)—"Reference Center to Support New Ventures." The resulting model, named "Amaral's Model for Innovation Environment Management" (AMIEM), was applied to five cases in Brazil. The empirical results are useful for analyzing such environments independently and for comparing them with a scoring system, based on the maturity level of each environment, which can be a way to evaluate the internal development and UIG linkages. These actors have developed in Brazil in the past 30 years in diverse innovation environments. However, several weaknesses in UIG linkages exist, and actions are necessary to promote enhancement, develop hybrid contexts and consensus spaces, and multiply experiences, creating more innovation and prosperity in the Brazilian economy.

Keywords: Science, technology and innovation parks, Business incubators, Assessment, Triple Helix, University-industry-government

JEL: O32, O31, M13, L26

Resumen

Este artículo describe y evalúa la gestión de entornos de innovación que resultan de los vínculos entre universidad, industria, y gobierno (UIG) tales como incubadoras de empresas y parques de ciencia-tecnología-e-innovación. El artículo también revisa la literatura reciente en la que se presentan y se combinan tres métodos diferentes: 11-Factores de Da Poian, Estrategigram, y el método Centro de Referencia y Apoyo para Nuevos Emprendimientos (CERNE).
El modelo resultante, que llamaremos Modelo Amaral de Gestión de Entornos de Innovación (AMIEM), se aplicó a cinco casos en Brasil. Los resultados empíricos son útiles para analizar este tipo de entornos de forma independiente pero también sirven para producir un sistema de puntuación basado en el nivel de madurez de cada entorno. Esta puntuación sirve también para comparar formalmente diferentes entornos así como para evaluar el desarrollo interno de los vínculos UIG. Estos actores han desarrollado en Brasil en los últimos treinta años en diversos entornos de innovación. Sin embargo, existen varias debilidades en vínculos UIG y ciertas medidas serán necesarias para promover su fortalecimiento, para desarrollar contextos híbridos y espacios de consenso, para multiplicar experiencias, para avanzar la innovación y prosperidad en la economía brasileña.

Résumé

Cet article décrit et évalue la gestion des environnements de gestion de l'innovation comme les incubateurs d'entreprise et les parcs de science, de technologie et d'innovation résultant des relations université-entreprise-pouvoirs publics (UIG). Il fait également la revue de la littérature récente de laquelle les trois méthodes émergeantes suivantes sont présentées et combinées; ce sont 11-Facteurs de Da Poian, Estrategigram, et la méthode CERNE (Centro de Referência para Apoio a Novos Empreendimentos – « Centre de Référence d'Appui aux Nouvelles Entreprises »). La méthode résultante appelée « Modèle d'Amaral pour la gestion de l'environnement de l'innovation » (AMIEM), est appliquée à cinq cas au Brésil. Les résultats empiriques sont utiles dans l'analyse indépendante de tels environnements et pour la comparaison avec un système de notation basé sur le niveau de maturité de chaque environnement qui peut être un moyen d'évaluer le développement interne des relations UIG. Ces acteurs se sont développés dans différents environnements au Brésil ces trente dernières années. Cependant, les relations UIG comportent plusieurs faiblesses et des actions sont nécessaires pour la promotion, l'élargissement, le développement des contextes hybrides, d'espaces de consensus, la multiplication d'expériences, la création de plus d'innovation et de prospérité dans l'économie brésilienne.

摘 要

本文描述和评价创新环境管理,如由大学-产业-政府(UIG)联系产生的商业孵化器、科技创新园区等。它也审查和综合在最近的文献中出现的三种不同的方法:即 Da Poian的11因素法、革兰氏战略和由CERNE(支持新冒险参考中心)开发的方法。我将由此产生的模型称为"阿马拉尔创新环境管理模式"(AMIEM),并将其应用于在巴西的五个案例。这个实证研究结果有利于独立地分析创新环境,有利于把它们与基于每个环境的成熟水平的评分系统进行比较,这可能是评估内部发展和UIG联系的一个(有效)方法。在过去的三十年间,在巴西,这些主体已经在不同的创新环境下发展起来。然而,存在着几个UIG联系的弱点,有必要采取行动促进发展混合环境和共识空间,积累经验,在巴西经济中创造更多的创新和繁荣。

Аннотация

Настоящая статья посвящена исследованию управления элементами инновационных систем, такими как бизнес-инкубаторы, научные, технологические и инновационные парки, основывающемуся на взаимодействии университетов, промышленности и власти. В работе также освещены актуальные публикации, в которых представлены следующие методы исследования: 11 факторов Да Пойана (Da Poian's 11-Factors), Эстратегиграмма (Estrategigram) и методика CERNE, разработанная Centro de Referência para Apoio a Novos Empreendimentos - Reference Center to Support New Ventures. Итоговая модель управления элементами инновационных систем AMIEM (Amaral's Model for Innovation Environment Management) была апробирована на примере пяти кейсов в Бразилии. Эмпирические результаты полезны для независимого анализа подобных систем и сравнения их между собой путем выставления баллов на основе степени зрелости каждой из систем, что может лечь в основу методики оценки внутреннего развития и связей между университетами, промышленностью и государством. Данные акторы сформировались в Бразилии в последние тридцать лет а различных инновационных условиях. Однако, в связях университет-правительство-бизнес имеются слабые места, что обуславливает необходимость активных действий, позволяющих стимулировать улучшения, реализовать возможности для выявления сфер пересечения интересов, диалога и обмена опытом, создавая более инновационную и процветающую экономику Бразилии.

Resumo

Esse artigo descreve e avalia a gestão de ambientes de inovação, tais como incubadoras de empresas e parques tecnológicos, de ciência e de inovação, resultantes das associações entre universidade-empresa-governo (UEG). O artigo também revisa a literatura recente, em que três métodos diferentes são apresentados e combinados: 11-Fatores de Da Poian, Estrategigrama, e o modelo CERNE (Centro de Referência para Apoio a Novos Empreendimentos). O modelo resultante, chamado de "Modelo Amaral para Gestão de Ambientes de Inovação" (AMIEM), foi aplicado em cinco casos no Brasil. Os resultados empíricos são úteis para analisar esses ecossistemas independentemente e para compará-los por meio de um sistema de pontos, com base no nível de maturidade de cada ambiente, o qual pode ser um meio de avaliar o desenvolvimento interno das redes de UEG. Esses atores se desenvolveram no Brasil nos últimos 30 anos, em diversos ambientes de inovação. No entanto, existem várias fraquezas existem nas redes de UEG, e são necessárias ações para promover a melhoria, desenvolver contextos híbridos e espaços de consenso e múltiplas experiências, de modo a criar mais inovação e prosperidade à economia brasileira.

Multilingual abstract

Please see Additional file 1 for translation of the abstract into Arabic.

Introduction

Since the 1970s, industrialized countries have enhanced the knowledge base of their economies, by the new techno-economic paradigm, based on the diffusion of communication and information technologies (Harvey 1992). So, there is a new concept: "knowledge-based economy," by means of which innovation becomes the element to provide competitive advantages to companies. Moreover, this is another important target of countries' policies (Etzkowitz 2008; Porter 2001).

This network economy, including its institutional participants, such as universities (U), industries (I), and governments (G), works in the production and delivery of knowledge, the production of goods and services, and the regulation of economic activity. It also operates through multiple interactions within nonlinear dynamics and hybrid and consensual contexts, by performing new roles, with overlapping, feedback, and emergence. The resulting product is known as the Triple Helix (TH) of university-industry-government (UIG) linkages, as found in the emergence of innovative environments such as business incubators (BIs); science, technology, and innovation parks (STIPs); and technology transfer/commercialization offices, among others (Etzkowitz 2008).

The literature on BIs/STIPs refers to these environments as responsible for promoting entrepreneurship and innovation and as essential elements for economic, social, and technological development (Zouain et al. 2013; Zouain et al. 2010; Figueiredo and Vedovello 2005). However, the discussion focuses mainly on the creation of these environments (Damiao et al. 2011; Vedovello and Godinho 2003; Vedovello 2000a, b; Magalhaes and Zouain 2010; Zouain et al. 2008) and how to promote entrepreneurship (Renault 2010; Carvalho 2009) rather than the management itself or the pursuit of success, in terms of development and effectiveness (Bouchardet 2012; Giugliani et al. 2012; Zouain and Plonski 2006; Cabral and Dahab 1998). This study fills in this gap by describing and

assessing the management of innovation environments. Five case studies were carried out, involving the analysis of success factors, using methodologies/models suggested to manage and assess BIs/STIPs.

About the structure, this paper has six parts: introduction, description of innovation environments, description of assessment mechanisms, research design, case studies' presentation and analysis, and final considerations.

Innovation environments

The TH approach was developed as an ex post concept, reflecting the reality of developed economies. Innovation is associated with the knowledge produced by research, development, and innovation (R&D&I) activities, conducted mainly by universities and collaborative networks with industry, supported by government (Renault 2010). There are different UIG linkages, depending on the objectives and degree of maturity in the environment. In the case of the TH1 configuration, the UIG spheres are not related to each other, in a typical disconnected and immature innovation system. In the TH2 configuration, the government covers the others, as in former communist and dictatorship states. Only in the TH3 configuration is their equilibrium of the spheres (Etzkowitz 2008).

Universities as entrepreneurs emerged originally in the USA, taking a leading role in the promotion of a knowledge-based economy, by producing the content that makes innovation possible for an entrepreneur. In this context, BIs form a common locus for knowledge/technology delivery and entrepreneur training, while STIPs exist as hybrid and consensus spaces (Etzkowitz and Zhou 2007). In a democratic context, BIs/STIPs can be understood as mechanisms for similar technology transfer processes but on different scales. There are mature BIs/STIPs, as innovation environments, in the case of configuration TH3, in which there is an overlapped interaction, though balanced, among the UIG actors, producing contexts for consensus (Amaral and Silva Filho 2008).

The business incubator is defined as a flexible and encouraging environment in which different possibilities for new entrepreneurship to emerge and grow are offered (Da Poian 2008). It is a mechanism for the acceleration of the entrepreneurship development process, maintained by governmental entities, universities, and civil society organizations, among others, with shared services and technical support, besides practical and professional guidance. Its objective is the creation of new ventures, financially viable and competitive in their market. The literature shows categories concerning modalities (pre-incubation/incubation/post-incubation), materiality (physical/virtual), focus (technology-based/traditional sectors/mixed/sector-based/multi-sector/agroindustrial/cooperatives/social/cultural/artistic, and project-based), and type of participation (incubated/associated/graduated) (ANPROTEC 2012; Maculan and Mello 2009).

In business incubation, the university leads in high-tech areas, where the main component is knowledge; industry leads traditional areas aiming to enhance organizational skills, and government leads in social incubators, to create jobs. Each UIG actor/sphere has a meaning and a specific role for each type of BI. In the Brazilian case, it was reconfigured from a mechanism of university knowledge transfer to space for the creation of entrepreneurship in diverse contexts, such as social and cultural, which could be called a "TH expanded model" (Etzkowitz et al. 2005; Zardo 2005).

The beginning of the BI movement in Brazil took place in 1984 when the National Council for Scientific and Technological Research (CNPq) created the Program to Support Technology Parks (PAPT). The pioneering incubator was established in the city of São Carlos, São Paulo state (Lahorgue 2004). At the end of 2012 (last survey available), there were 384 active BIs in Brazil. There were 2509 graduated companies with revenues of R$4.1 billion (±US$2 billion), employing 29,205 people, with a mortality rate below 20 %. Besides that, there were 2640 incubated companies and 1124 fellow companies. More than 40 % of Brazilian federal universities have BIs (MCTI 2013; ANPROTEC 2012; Etzkowitz and Mello 2004).

In terms of financial and technical support, there are actions from the CNPq and the Brazilian Service to Support Micro and Small Businesses (SEBRAE). CNPq has promoted the creation/development of BIs/STIPs since the mid-1980s. SEBRAE has supported BI creation since 1991. In 2000, a specific program to support Brazilian incubators was launched, for creation/consolidation and articulating actions from several agencies (Wegermann 2010).

According to the International Association of Science Parks (IASP), a technological park is an organization managed by specialized professionals that aims to increase the local community's wealth by promoting innovation culture and industrial and institutional competitiveness. In order to do this, the park needs to encourage and manage the flow of knowledge/technology among the university, research and development (R&D) institutions, industry and market; to simplify the creation/development of innovative companies through incubation; and to provide services with value added, besides physical space. Other terminologies known are science parks, innovation parks, poles, and technopolis.[1] Nowadays, STIPs emerge in contexts of regional economic development. Their aims are to support the development of innovative and high-tech goods/services, the creation of new ventures, and the promotion of UIG linkages (Wegermann 2010).

The STIP idea appeared almost spontaneously due to the interaction between academic research and companies. The first and most successful situation took place at Stanford University, in California, between the 1930s and 1940s (and formally launched in 1951). Such initiative inspired entrepreneurship around the globe. In Brazil, this happened after the start of the Program to Support Technology Parks in 1984, with the creation of high-tech park foundations. In 1987, these entities established the National Association of Promoters of Innovative Ventures (ANPROTEC). From 1984 to 1992, the discussions were focused on poles and parks (Wegermann 2010).

The conditions for the implementation of the STIP mechanism evolved over the following decades. In 2003, before the enactment of the Innovation Law from 2004, there were 33 parks in project, deployment, and operation, with nearly 130 companies, concentrated in Brazil's south and southeast regions. There was a relevant presence of universities, to which 70 % of the STIPs claimed to have formal links (Lahorgue 2004). In 2013, there were 94 STIPs operating and being deployed (MCTI 2013). However, the Brazilian movement is less developed/mature in relation to the leading economies.

In sum, BI and STIP are both mechanisms for technology transfer, using similar processes, though at different scales. In general, BI is more focused on dealing with entrepreneurs and start-up companies while a STIP can work with a wide range of people (academics, businessmen, entrepreneurs), ventures/projects, and organizations (small/big companies, public/private labs, academy, etc.) (Amaral and Silva Filho 2008).

Assessment of UIG mechanisms

A literature review on BIs/STIPs was performed to set a model of overall assessment. Da Poian (2008) developed a method for determining key factors for success. The Estrategigram, a proposal from Luis Sanz, IASP's general director, is a theoretical model without empirical implementation. The assessment/certification of BI models according to the framework recommended by Centro de Referência para Apoio a Novos Empreendimentos (CERNE), developed by ANPROTEC, was the last one studied.[2]

Da Poian (2008) studied 12 BIs/STIPs in Brazil, Uruguay, Italy, and France[3], and described a set of 11 factors for the management and multidimensional assessment model. The success of a BI/STIP depends on several general aspects: (i) attracting R&D units/projects and producing useful knowledge, (ii) stimulating the emergence of new organizations through incubating and spin-off activities, (iii) contributing to knowledge transfer and dissemination, and (iv) developing activities of "technological advertisement," understood as the promotion of technical (courses, seminars, congresses) and social events (award ceremonies, breakfasts, brunches). The 11 specific factors are presented below.

1. Time frame: Innovation environments need to go through a maturity process, in order to make their infrastructure and financial supporting mechanisms more organized, to have their specific regulations approved, and to help society understand their idea. Before a period of 5-8 years, it is hard to conclude that an initiative is unsuccessful. However, if the success indicators (developed technologies and graduated companies) do not begin to emerge after 10-12 years, the project falls into discredit.
2. Governmental support: It is crucial to provide infrastructure, funding, and tax breaks or incentives to make successful entrepreneurship possible. The presence of local governments reveals the perception that an innovative entrepreneurship will help boost the local or regional economy.
3. Participation of the local community: The mobilization of entrepreneurs and representative entities, as well as the mobilization of media, is important to consolidate BIs/STIPs, even if the main anchors come from outside of the region.
4. Involvement of universities/research institutions: The presence of universities and R&D institutions is fundamental to help companies find technical support for new entrepreneurship. The management staff must encourage these institutions to improve their participation in the business scenario, through collaborative projects, provision of technical services (lab testing and prototype development), and patenting/licensing, among others.
5. Support from funding sources: This is essential for infrastructure projects and to enhance the surroundings, as well as for the execution of feasibility studies and promotion/publicity activities. The creation of a public and/or private venture funding for entrepreneurs and infrastructure implementation is important. In some cases, BIs/STIPs have to set up investment funds, for the promotion of R&D activities and/or the capitalization of new ventures. Several support actions from the Brazilian Innovation Agency (FINEP), CNPq, and SEBRAE stand out.
6. Anchor companies/institutions: The attraction of relevant companies, as well as academic institutions, is fundamental to influence other companies' decisions.

Governments can do this by transferring public facilities to the STIP and encouraging public sector companies to do the same.

7. Physical space: This includes urbanization, availability of transportation and communication infrastructure, landscaping to create pleasant environments, and construction of buildings with suitable premises at low costs for smaller companies, among others. Some projects are contained in single facilities while others are geographically distributed.
8. Management structure: BIs/STIPs need a competitive, dynamic, creative, and affordable management structure, to attract companies and offer their services. In general, the management structure is small, with few experienced staff taking care of publicity, attraction of business, management, service provision, and sales promotion (including opening external markets). Moreover, the creation of cooperative networks among companies in terms of the use of services and equipment, and to publicize the scientific-technological knowledge, is important.
9. Leadership: It is necessary to have distinguished, devoted, active, persistent, and skillful leadership units, able to overcome barriers. The figure of an organizational leader is important: the person with the original dream/idea who fought to convince UIG actors and society about a particular BI/STIP. These people stand apart from the local leaders of BI/STIP staffs.[4]
10. Publicity/promotion/advertisement: This is useful to attract companies, obtain financial and political support, and maintain a high level of satisfaction among entrepreneurs. Successful entrepreneurship settings are related to wide promotion/publicity, through courses, seminars, congresses and visits, among others.
11. Good living and working environment: The concentration of activities with a high technological creation content needs a high level of engagement, for which it is fundamental to offer a pleasant working environment. The attention to architectural design has been fundamental in the successful development of BIs/STIPs. The same applies to the quality of life of executives/employees and their families. In these respects, the involvement of the government is important to deal with themes as mobility, communication, education, health assistance, leisure, and cultural activities.

The so-called Estrategigram was the second model examined. It was proposed in 2006 to formulate the STIP strategy based on seven axes, summarized below (Sanz 2006). Each one can be scored between 10 (positive) and −10 (negative). A final index can be empirically verified, and the innovation environments can plan their enhancement goals in the short/medium term. Such a tool can be used by both researchers, when measuring the impact of innovation environments, and promoters when making decisions (ABDI 2007).

Axis 1 location: The geographical location and the degree of urbanization and other elements that make up a space (such as living areas, services, and utilities).
Axis 2 technology source: The involvement of the STIP and its sources of knowledge/technology, its receivers and users.
Axis 3 place x attraction: The ability to attract/retain or create/develop technology-based companies.
Axis 4 kind of business: The degree of specialization, in a technology segment or many technologies.

Axis 5 market focus: The strategies adopted to attract local/regional or foreign/multinational businesses.
Axis 6 networking: The strategies to form alliances and operate in cooperative networks,
Axis 7—governance: The management structure (management of assets and properties).

The last model from the literature is that developed by CERNE. It is a reference to support BI management in Brazil, used by 123 BIs as a certification tool. For this, it determines best practices in several key processes (organized in systems) that are associated with four maturity levels. It is a platform that aims to promote improvement in BI results with focus on the following aspects:

1. Venture support: processes related to the companies' operational support (development of products and services, capital and market access, business management and promotion of entrepreneurship)
2. Operational processes: to enable the transformation of ideas into businesses (exploration, generation, development, and graduation of innovative enterprises)
3. BI management: to deal with finance, people, and networking, among others.

Each maturity level shows the ability of a system compounded by a set of processes. Table 1 shows the key systems (ANPROTEC 2012).

Research design

This study is part of an effort to propose and apply a new analysis and management model. The review looked at the recent literature on the subject in Brazil (MCTI 2013; ANPROTEC 2008, 2012; Amaral and Wegermann 2011; Amaral et al. 2010, 2009; ABDI 2007) and references already cited in the introduction.

Due to its good level of detail and previous application, the "Da Poian 11-factors" model was the base of the new mixed model, named "Amaral's Model for Innovation Environment Management" (AMIEM). Each axis of the Estrategigram was compared with the 11 factors suggested by Da Poian. The analyses showed that all themes covered by the axes overlap with the 11 factors. So, it was possible to incorporate the seven axes in the Da Poian model. Then the CERNE model was analyzed. Its focus on internal management aspects (operations and strategy) allows the consolidation of most of the processes with the factor "Management Structure" from Da Poian. A new factor named

Table 1 CERNE structure

Maturity level	No. of processes/ accumulated	Systems (of key processes)		
		Ventures support	Operational processes	BI management
1	36/36	Selection; development of companies	Attraction/prospection; graduation	Basic management
2	12/48	Expansion of the limits	Incubator evaluation	Strategic management
3	10/58	Network development	Institutional relationship	Social and environmental responsibility
4	4/62	International operations		

Source: ANPROTEC (2012); author's tabulation

"Governance and operational management" was created in the AMIEM. Table 2 shows the model's consolidation.

The AMIEM is qualitative, applied in semi-structured interviews and can be treated by content and/or discourse analysis techniques (not done here). Furthermore, to allow case comparison, it involves a quantitative assessment. Each of the AMIEM 11-factors can be scored on a Likert scale (1 corresponding to "bad/unimportant," 2 to "reasonable/medium," 3 to "good," and 4 to "very good/excellent") (Carifio and Perla 2007). Each factor should also be weighted in terms of relevance, assuming that each BI/STIP is in a different stage of UIG linkages and has a different model, priorities, and strategies. The weights are 1 for low importance, 2 for medium importance, and 3 for maximum relative importance of the factor.[5] However, the sum of weights is limited to 25 (range from 11 to 25), so that the highest relevance of all factors will not be greater than 100 points.[6] BIs/STIPs located between 75/100 points (top quartile, defined arbitrarily), shall be considered as highly mature; in the range from 50 to 75 points, it is an intermediate maturity level. At last, under 50 points, it is a lower maturity level of UIG linkages.[7]

The application of AMIEM is supported by case studies. These studies were carried out during the second half of 2010 in the five selected organizations, in the two steps: previous collection of information/data in documents and the internet, and generation of information/data by interviews with managers following a semi-structured script and responses to questionnaires.[8]

After the first visit, there was a contact with the managers in 2011, 2013, and 2015. The evolution of the factors was monitored and in the case of some significant change, the results were updated. In one case (business incubator of Universidade Federal Fluminense (BIUFF)), there were two new visits (2013/2015), due to changes in managers and operational aspects. They received a manuscript to approve qualitative information

Table 2 AMIEM consolidation

AMIEM's 11 factors	Da Poian's 11 factors	Estrategigram's axes	CERNE's levels
Time frame	Time in location		
Governmental support	Governmental support	Networking	
Participation of the local community/networking	Participation of the local community	Market focus; networking	Social/environmental responsibility; network development
Involvement of universities and research centers	Involvement of U's and research centers	Technology source; kind of business	Institutional relationship
Support from funding and promotional agencies	Support from funding and promoting institutions	Networking	Institutional relationship
Presence of leading companies and institutions	Presence of anchor industries and institutions	Place *x* attraction	Network development, institutional relationship
Physical space and location	Physical space	Location	
Governance and operational management	Management structure	Governance	Basic and strategic management
Leadership	Leadership	Governance	
Publicity/promotion/ advertisement	Publicity/promotion/ advertisement		
Living and workplace quality	Quality of life and working conditions		

Source: author's tabulation

and analysis. In few cases, adjustments were made due to mistakes in the interpretation or incomplete information.

Case studies

Four BIs and one STIP were selected for the application of the AMIEM. The choice was made due the importance of these actors in Brazil. It was a nonstatistical sample. Environments with different characteristics were selected (created during the 1980s, 1990s, and 2000s; BIs combined or not with a STIP; hosted by a public or private university).

Innovation environments

The Center for Technology Development in Universidade de Brasília (CDT/UnB) was created in 1986. Its mission is to promote and support entrepreneurship and technological development through interaction between UIG and society (http://www.cdt.unb.br). CDT/UnB's vision is to become a center to support innovation in technology management, technology transfer, and entrepreneurship. It aims to strengthen the economy and to support society in the region, through job and income creation, while participating in the dissemination and transfer of knowledge produced by the university to industry, both via consultancy and consolidation of ventures. It is responsible also for managing cooperative projects in education and research. It operates with a group of projects, from the multi-business incubator, with technological, social, and supportive incubators, also using art and culture; and with a STIP.[9]

As an entity of Universidade Federal do Rio de Janeiro, recognized as the leader in innovation and technology in Latin America, The coordination of graduate programs (COPPE) h andles 16 engineering courses, with a strong linkage with industry. In this context, the technological BI (ICOPPE) started in 1995 located at Cidade Universitária da Ilha do Fundão (http://www.incubadora.coppe.ufrj.br).[10] It has two buildings that can house up to 30 companies. The 20 resident companies and the 48 graduated ones have revenues of R$222 million in 2014 (±US$110 million). The BI is part of the Technology Park of Rio de Janeiro, a STIP with 350,000 m^2 (Renault 2010).

The BIUFF, in Niterói, Rio de Janeiro state, has existed since 1999. In 2007, it was restructured when the INITIA Laboratory for Innovation and Entrepreneurship was created (Amaral and Silva Filho 2008). In 2010, there was a second restructuring and the INITIALab became a BI of the Instituto Vital Brasil, with a focus on biotechnology, while the technological BI remained at Universidade Federal Fluminense (UFF) (http://www.incubadora.uff.br), with the purpose of establishing a network of R&D and innovation activities. In 2015, it has four operational companies and ten entrepreneurial projects.[11]

The Gênesis Institute of Pontíficie Universidade Católica of Rio de Janeiro (IG/PUC-Rio) includes the areas of business creation, entrepreneurial culture, and local development promotion. IG/PUC-Rio operates three incubators: culture, social, and technological (www.genesis.puc-rio.br). Since its opening in 1997, the incubated and graduated companies have received nearly 50 awards, which makes IG/PUC-Rio probably the most successful BI in the country. In 2002, it started to work in the culture industry, creating the first cultural incubator in Latin America, after identifying demand for entrepreneurial projects in this area. In 2004, it launched the social community incubator, aiming to strengthen communities via entrepreneurial training programs.[12]

The São José dos Campos Technology Park (PqTec-SJC) is part of the São Paulo System of Technology Parks, created in 2006 (http://www.pqtec.org.br/). Its management is under the responsibility of an association that takes care of land and activities. Based on the TH approach, PqTec-SJC has the mission to promote interaction of UIG and promotional entities. It aims to generate technology innovation, by creating new technology-based companies, enhancing industrial competitiveness, revitalizing the regional economy, and creating jobs. Its vision is the convergence of the ideals of people working in government, with focus on notions of collective competitiveness as the target for innovation environments. A long-term vision is established, consisting of three phases: structuring (2–3 years), expansion (5–6 years), and consolidation (12–15 years). Currently, it has five centers for technology development, 25 operating companies, and an incubator called CECOMPI with 25 incubated companies.

Table 3 summarizes the basic information.

Qualitative analysis

Regarding the time to reach maturity, the BIs/STIPs had different experiences. It took PqTec-SJC only 2-3 years to collect the initial results while CDT/UnB took 8 years. It took 5-7 years for ICOPPE/UFRJ to reach maturity and 7 years for IG/PUC-Rio. BIUFF had diverse cycles, the current of which (past 4 years) has not led to a higher level of maturity (no companies graduated).

Government support is present in the case of PqTec-SJC and CDT/UnB. The other three examined organizations receive occasional aid. In the case of ICOPPE/UFRJ and IG/PUC-Rio, both are located in the city of Rio de Janeiro and they compete for local government support. Moreover, there is another BI/STIP in the state of Rio de Janeiro, which may explain the inexistence of a more continuous supporting action from the state government. BIUFF was created with funding coming from the Niterói city government, but the support did not continue, partly explaining its cycles and low maturity.

The participation of the local community and networking competencies are limited. In the case of IG/PUC-Rio, associated with a private and religious institution, the incubation is restricted to internal students and researchers. Nevertheless, the BI is well known and networked. The main linkage is with former companies and former students. As an example, some businesspeople organized a group of angel investors called Gavea Angels. In the case of ICOPPE and CDT/UnB, the incubation process is open to any person, regardless of the relationship with the university. Nevertheless, most applications come from students and researchers. They are much more recognized by government and external organizations through media than by internal community. Between 2007 and 2010, BIUFF received external ventures, but this was the subject of criticism from the internal community, due to the lack of physical space. In the current configuration, academic spin-offs from the internal community are the focus, but part of the community does not accept this university rule. In the case of PqTec-SJC, the linkages are stronger with big local companies and state government. Anyone can look to the BI to host a venture. Entities like FIRJAN, SENAI, SEBRAE, and various trade associations are involved, but civil society organizations and media companies, in general, do not take part in the BI/STIP movement.

Table 3 Basic information on the five BI/STIP cases

Indicators	CDT/UnB	IG/PUC-Rio	PqTec-SJC	ICOPPE/UFRJ	BIUFF
Year of creation	1986	1997	2006	1994	1997
City	Brasilia-DF	Rio de Janeiro-RJ	São José dos Campos-SP	Rio de Janeiro-RJ	Niterói-RJ
No. of incubated companies	23 (1)	22 (1)	25 (2)	20 (1)	4
No. of graduated companies	18 (1)	60 (1)	0	48 (1)	0
Incubation period (years)	2-3	2	2	2	N/A
Revenue of companies	N/A	R$853 M/(US$244 M)	N/A	R$222 M/US$110 M	0
Built area (m^2)	500	400	36,000	1900	200

Source: Author's tabulation based on last data available (2014)
(1) only technological BIs, *(2)* technological BIs and STIPs, *N/A* not available

The development of linkages with university and research institutes is a fact in all cases. However, IG/PUC-Rio is exclusively related to PUC-Rio. In the cases of BIUFF, ICOPPE/UFRJ, and CDT/UnB, they are linked to the host university and with other surrounding institutions (like Vital Brazil in the case of BIUFF). ICOPPE/UFRJ is also related to foreign universities. Only PqTec-SJC has major difficulties, because it is not hosted inside a campus. However, it has been working to rectify this situation by forging ties with universities and research centers, such as state and federal universities in São Paulo (Unesp and UNIFESP).

In terms of the support coming from funding and promotional agencies, IG/PUC-Rio does not have monthly contributors and only counts with the support coming from contributors. Thus, it has to look for projects with SEBRAE and FINEP to financially support itself. PqTec-SJC has support from companies, such as Embraer, besides the traditional research funding actors, like the São Paulo State Research Support Foundation (FAPESP). CDT/UnB counts on support from FINEP, SEBRAE, and the National Bank for Economic and Social Development (BNDES). BIUFF receives support from the university itself and projects with SEBRAE, FINEP and Petrobras. In ICOPPE/UFRJ, there is support via projects funded by FINEP, CNPq, FAPERJ, SEBRAE, and firms like the oil company OGPar, among others. Some BIs, as ICOPPE/UFRJ, receive a monthly contribution, in case a company wants to access the development technologies. In the case of PqTec-SJC, there is a similar contribution through purchasing research and project results.

Leading companies are also present in all of them, except for BIUFF. In ICOPPE/UFRJ, there are anchor companies such as Petrobras, on the campus of UFRJ. PqTec-SJC, IG/PUC-Rio, and CDT/UnB are also supported by companies. IG/PUC-Rio and CDT/UnB are involved with local development, incubating companies that can later act in the region. Since Brasilia is not an industrial city, the organization interacts with a limited number of companies. However, the collaboration with the local government is good and has formed a good network of relationships. Some graduated companies are also leading companies in their sectors, like PipeWay (IG/PUC-Rio), specialized in pipeline inspection and management, and Pam-Membranas (ICOPPE/UFRJ), a maker of filtration membranes. These companies depend on the maintenance of the linkages via projects and installing laboratories, besides coaching. In the case of PqTec-SJC, there is an emphasis on attracting regional companies, like aircraft company Embraer, in order to promote regional development.

All environments are potential users of technologies developed by incubated/graduated companies, besides promoting them. ICOPPE/UFRJ implemented management software created by another incubator. IG/PUC-Rio uses content management and website tools created by graduated companies (Fábrica Digital and Lumis).

Regarding internal variables, such as physical space, amenities, and location, BIUFF and IG/PUC-Rio have limitations and no forecast for expansion. PqTec-SJC has a large expanding structure available, as does ICOPPE/UFRJ, through its STIP. CDT/UnB is also expanding, to enable it to provide space for new ventures.

Regarding governance, operational management, and leadership, most of the organizations count on management teams that are regularly renewed. In the case of PqTec-SJC, there is a 4-year term with one reappointment. ICOPPE/UFRJ has a fixed governance, coming from the university and executives from outside COPPE. PqTec-

SJC, CDT/UnB, and IG/PUC-Rio have more horizontal structures, with low hierarchy and some autonomy. An informal environment is established, allowing the staff to contribute ideas and to develop personal projects. Every organization counts on people involved with innovation, idea generation, and entrepreneurial attitudes, despite the low levels of formal training in the area. CDT/UnB, IG/PUC-Rio, and ICOPPE/UFRJ adopt CERNE as a management tool. The self-evaluation puts CDT/UnB at level 4 and the other two at level 1.

In terms of publicity/promotion/advertisement, all of them offer courses, lectures, and workshops for the local community. However, there is little publicity of the activities. ICOPPE/UFRJ is working to change this situation, while IG/PUC-Rio has a unit that handles communication/marketing. Lastly, PqTec-SJC is also taking actions to promote better communication.

Regarding the working environment, all the organizations have creative environments that are open to innovation, with freedom, flexibility, and, simultaneously, pressure and constant challenges. In the case of BIUFF, the university's red tape slows down the activities, which produces frustration. This has an impact on the quality of life in the workplace. In terms of the physical environment itself, the most pleasant environment is CDT/UnB. However, only PqTec-SJC reported that special attention had been paid to the architectural design of the business park. The environmental sustainability is part of managers' discourse, but except for waste recycling, no effective actions were found.

Table 4 summarizes the field research information.

This analysis shows success in a diversity of experiences, with success being defined as the presence of UIG actors and several mutual links. The general pattern is the greater the number of links, the greater the degree of innovation maturity and success. Success has come only slowly to ICOPPE/UFRJ and CDT/UnB, probably because the innovation framework in Brazil took almost two decades to evolve. PqTec-SJC reached success quickly due to the policy and investment from the São Paulo state government. Only BIUFF has not achieved success.

Quantitative analysis

The quantification of AMIEM should in general present similar results as the qualitative analysis. However, the translation of words into numbers revealed additional opinions/positions. For instance, the quantitative approach identifies more relevant factors that need to be more closely considered to overcome possible barriers. The assessment also depends on other success indicators, such as the number of ventures, the companies' revenue, the ability to win competitive projects and attract resources, the number of jobs, and companies created.

Table 5 shows how each organization was assessed. There are evident differences in how each of them is perceived, both from the viewpoint of each member and from the organizations themselves. In the case of ICOPPE/UFRJ and IG/PUC-Rio, the questionnaire was answered by the main managers, while in the case of BIUFF, it was answered by the director at the time (2011) and then reviewed by the current director (2013). In the other cases, the questionnaire was answered by the people responsible for each area. There are clearly different perspectives, views, and levels of self-

Table 4 AMIEM application

AMIEM factors	CDT/UnB	IG/PUC-Rio	PqTec-SJC	ICOPPE/UFRJ	BIUFF
Time frame	Created in 1986; 8 years until reaching maturity.	Created in 1997; 7 years to achieve current maturity level.	Created in 2006; 2-3 years to achieve current maturity level	Created in 1995, 5-7 to achieve current maturity	Created in 1999; some cycles
Governmental support	Yes, local government	Yes, on a project-by-project basis	Yes, from the state and local government	Yes, on a project-by-project basis	No support from local government; only on a project-by-project basis
Participation of the local community/networking	Yes, different courses and events realized	A relationship with PUC-Rio is necessary to be eligible for incubation	Focus on companies	Researchers/students	Internal conflicts
Involvement of universities and research centers	Mainly from UnB	Exclusively with PUC-Rio	Yes, such as Unesp, ITA, Unifesp, among others	COPPE/UFRJ and research centers in Brazil and abroad	UFF and Vital Brasil
Support from funding and promotional agencies	UnB, FINEP, SEBRAE, BNDES	PUC-Rio, FINEP, SEBRAE	FAPESP, Embraer	UFRJ, SEBRAE, FINEP, FAPERJ, CNPq, OGPar, Petrobras.	UFF, FINEP, SEBRAE, Petrobras.
Presence of leading companies and institutions	No	Graduated companies	Yes, Embraer	Petrobras	No
Physical space and location	Recent expansion. 500 m^2	Not enough. Area ±300 m^2.	Adequate and expanding.	It is being expanded, but not enough.	Not enough. Area ±200 m^2
Governance and operational management	Some autonomy from UnB. Four key management positions and horizontal structure.	PUC-Rio's unit with some autonomy. Divided into areas with specialized management team	Management team changes every 4 years. Contracted staff members.	COPPE/UFRJ's unit, but with a permanent team and some autonomy	Part of the Innovation Agency of UFF, without autonomy
Leadership	The same group of managers from the beginning	One general director and three managers of key areas	Not identified	One director and managers by area	One director and project leaders
Publicity/promotion/ advertisement	Advertisements in communities surrounding Brasilia; large-scale publicity; various events	There is an area devoted to publicity. Support from PUC-Rio	Both from the park fees and local government's part and also through events	Fairs, events, student integration programs	Through events and seminars; little known in and outside UFF
Life quality and work environment	Encouraging, challenging, good quality of life	Excellent. There is freedom, flexibility, little competition, opportunities to share opinions and to develop personal projects	Adequate, encouraging, challenging	It is going through some growth crises	Tiring, given the excessive red tape at UFF

Source: MCTI (2013); ANPROTEC (2012); Wegermann (2010); author's tabulation

Table 5 Self-assessment

AMIEM 11-factors	PqTec-SJC		IG/PUC-Rio		CDT/UnB		ICOPPE		BIUFF	
	Importance	Score	Importance	Score	Importance	Score	Importance	Score	Importance	Score
Time frame	1	4	1	4	1	4	1	3	1	1
Governmental support	3	4	2	2	2	4	3	2	1	2
Participation of the local community/networking	2	3	2	3	3	4	2	2	3	1
Involvement of universities and research centers	3	3	3	3	3	4	3	2	3	2
Support from financial and promotional agencies	2	3	3	3	3	4	3	2	3	1
Presence of leading companies and institutions	3	4	1	3	1	4	3	3	3	3
Physical space and location	2	3	2	2	2	4	1	3	2	1
Governance and operational management	3	3	3	3	2	4	2	2	1	3
Leadership	2	3	3	4	2	4	3	3	3	2
Publicity/promotion/advertisement	2	1	2	2	3	4	2	2	2	1
Life quality and work environment	2	3	3	4	3	4	1	3	3	1
Sum = ∑ (importance *x* score)	78		76		100		57		40	

Source: Wegermann (2010); author's tabulation

criticism. It might have been better to implement the assessment with several managers from each of the environments. However, this could make the assessment/examination and data treatment more complex (there is no happy medium). Besides that, aspects like the available time to complete the research and the seriousness with which it was conducted should be considered.

From the self-assessment, it is possible to confirm the high relevance of university involvement to all BIs/STIPs, followed by "Leadership" and "Presence of leading industries and institutions." The less relevant aspects to BIs/STIPs assessed are "Publicity/promotion/advertisement" and "Time frame."

For CDT/UnB, the self-assessment was not efficient. The small level of self-criticism avoided any deep analysis. ICOPPE/UFRJ had a conservative assessment and an excessive standard for self-criticism. Due to its companies' revenue and number of graduated ventures, an external observer could give higher scores. In the case of BIUFF, the organizational and management changes perhaps slowed the evolution of UIG linkages. The current manager of UFF's Innovation Agency is trying to unlock the BI potential, but this effort is suffering from the low technological culture and low involvement of the faculty (Wegermann 2010; Carvalho 2009).

Confronting two perspectives

In the search for general characteristics and identification/assessment of behavior patterns, the AMIEM made it possible to understand the environments better. For example, ICOPPE/UFRJ has the basic configuration of a technology incubator, as described in the literature, with a sectorial focus, and provides infrastructure and support services. It is a BI coming from a top-level R&D academic institution, with a TH3 configuration with strong UI relationship. BIUFF has tried to follow the same strategy, but has not succeeded, perhaps due to the poor culture of innovation and the low UIG articulation.

Regarding the maturity assessment measures, IG/PUC-Rio and PqTec-SJC have similar performance. PqTec-SJC showed the highest level of UIG linkages: the companies involved behave effectively, and both local and state governments provide assistance and have representation on the board. Therefore, PqTec-SJC could be classified in the configuration as TH3. In the case of PUC-Rio, there is a strong entrepreneurial environment and an effective university-industry linkage that allows the rapid growth of new companies. An example is that of angel investors organized in an association called Gavea Angels.

The results of both analyses indicate that ICOPPE/UFRJ is close to IG/PUC-Rio and perhaps PqTec-SJC is not so developed. PqTec-SJC is a STIP without a university at the time of its creation, but it has evolved given the suitably structured UIG link, "leveraged" by the government. TH3 configuration is a target (it is part of PqTec-SJC's mission), but the university is not there to lead. This can introduce a new theoretical discussion to the TH idea. IG/PUC-Rio and CDT/UnB stand out as complex environments, with three incubators, each with different performances. They can be categorized with the TH expanded model while each is shaped by a different set of UIG linkages.

In every BIs/STIPs examined, there was a noticeable effort to place them as an entity of consensus within the UIG framework, according to the TH proposed. We identified tripartite/blended councils, collaborative innovation projects, and formal and informal activities to promote integration, among other aspects. However, some drawbacks were also found, like:

1. Lack of BI/STIP management competencies is a common problem. The analysis identified a lack of experience in dealing with participants' diversity, in the case of management staff, which causes a lack of measures to keep environment evolution on track. CERNE is an attempt to fill this gap.
2. Universities need to improve their ability to deal with innovation mechanisms. Innovation activities are different from teaching/research/outreach. This is the reason because organizational and cultural changes to make universities more entrepreneurial are necessary, as argued in the TH approach. The autonomy level of the BIs/STIPs from their institutional host is a key aspect. Comparison between PqTec-SJC and BIUFF reinforces this argument. Technology transfer office seems passive in the management of industrial property rights and assets.
3. The government's participation, mainly the local one, needs to be active, for wherever government is not present, maturity levels are low. However, in general, local governments do not have the ability to deal with an innovation environment, because political aspects overlap technical ones. Leadership and networking are essential to overcome this challenge.
4. The industry needs to get closer. The level of firm R&D&I investment in Brazil is low, and the industrial system works apart from the innovation system (Silva 2011). The Brazilian economy is huge, but centered in big national and foreign companies. The PINTEC[13] evidences (just 1.66 % of GDP in R&D&I effort, 55 % done by the government) reinforce the idea that the innovation system is apart from the production system. As a characteristic of least industrialized countries, the gross of Brazilian companies' investment in innovation is the acquisition of foreign machinery (MCTI 2013). Entities like ANPOTEC and SEBRAE are crucial to create consensus spaces.

Final considerations

This paper focused on the assessment of the innovation environment management. Three models were studied, and a new one was proposed to achieve the consolidation of factors, axes, and processes. The AMIEM was applied in five case studies, helping to examine the success factors.

One consideration is about the evolution of innovation environments in the last 30 years toward a national innovation system. BIs/STIPs, ANPROTEC action and Innovation Law were drops in the ocean of Brazilian economy. BIs/STIPs graduated close to 6,000 ventures since the 1980s in the scenery of 15 million firms. Just a few graduated companies grew turning into leaders in significant markets. Therefore, it is necessary to increase the level of TH linkages to improve mature hybrid and consensus spaces, while reproducing innovation environments in a large scale to promote economic prosperity.

In terms of this research, the proposition and application of a model is a valid contribution to the discussion of innovation environment management. The work has several limitations and possibilities. Some arbitrariness in the model construction can be criticized, as well as the reductionist approach of some themes. The relationship between AMIEM and other models needs more reflection. In terms of possibilities, in an application within a BIs/STIPs, it is possible to collect more information from managers, staff, and also from firms (users), supporters, and stakeholders as a whole and make an analysis of the perception of each segment and confront them. Also, a comparison

between similar BIs/STIPs and case studies within different regions and countries can be explored in the future. Moreover, this also can help enhance the AMIEM.

Endnotes

[1]We employ STIP as a general term, without analyzing differences between the terminologies.

[2]The Cabral-Dahab paradigm was not considered because it seems more a set of recommendations than a management tool and it is not supported by any association like ANPROTEC or IASP.

[3]Italy: San Raffaele, Kilometro Rosso, Torino Wireless, Area, and Incubator I3P. France: Sophia Antipolis. Brazil: Vale da Eletrônica, Porto Digital, COPPE, Petrópolis Tecnópolis, and São José dos Campos. Uruguai: Zonamerica.

[4]Examples of people who have been recognized on innovation circles as institutional entrepreneurs of BI/STIP are French former Senator Pierre Laffitte, mentor of Sophia Antipolis; Maurício Guedes, Director of UFRJ's park; and José Alberto Aranha, Director of PUC-Rio's Genesis Institute.

[5]For example, for a STIP, the need for land/facilities from the local government is more important than to a BI, in general. So, the Government Support and Physical Space factors will be more relevant (and weighted).

[6]There is a discussion in social sciences of whether it is possible to calculate averages with scores of a Likert scale, due to the ordinary aspect of each answer. Here, I do not compute averages, only sums (Sanches et al. 2011).

[7]Amaral et al. (2010) applied the "Da Poian 11-Factors" in Sophia Antipolis Park (SA), France, and in Petrópolis Tecnópolis Park (PPT), in the State of Rio de Janeiro. SA obtained 86 points and PPT 53 points, reflecting the maturity differences between them.

[8]Except for one respondent, who answered the assessment in person, the questionnaire was sent by e-mail.

[9]The research focused only on technological BI.

[10]COPPE has a BI for social cooperatives that was not studied here.

[11]The activities were examined after 2007 and only inside UFF.

[12]In this case, the three BIs were examined from the management viewpoint, because they are operated together.

[13]Brazilian Innovation Survey. Data from last survey in 2013.

Additional file

Additional file 1: Translation of the abstract into Arabic. (PDF 390 kb)

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